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ABSTRACT

This study explored ways of developing and utilizing more efficient Computer-Based Instructional Simulations (CBIS) based on the relationship among fidelity levels (i.e., how closely a simulation imitates reality), transfer time, and learning time. The hypotheses presented suggest how to determine the optimal shifting points of the fidelity levels; this method yields the optimal routes that would help learners reach goals with less time in CBIS. To verify the hypotheses, 148 seventh grade male students were selected voluntarily from one junior high school in Korea, and a 4 X 6 (Fidelity Levels X Number of Lessons) posttest-only experimental design was employed. Even though the result failed to support main hypotheses due to no distinct difference among fidelity levels of CBIS, the result shows that a cost-effective point on learning time exists in a given level of fidelity range of CBIS. Therefore, the hypotheses need to be tested again in further well-designed experiments with a larger range of fidelity. Figures illustrate the relationship between transfer of learning and learning time according to fidelity levels and the optimal shifting of fidelity levels and its benefit. A table of the standards for classifying fidelity levels is included. (Contains 23 references.) (Author/DLS)

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ED 423 829

Optimal Shifting of Fidelity Levels in Computer-Based Instructional Simulation

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Abstract

The purpose of the study seeks ways of developing and utilizing more efficient Computer-Based Instructional Simulations (CBIS) based on the relationship among fidelity levels ("how closely a simulation imitates reality"), transfer of learning, and learning time. The hypotheses presented in this study suggest how to determine the optimal shifting points of the fidelity levels; this method yields the optimal routes that would help learners reach the goals with less time in CBIS. To verify the hypotheses, 148 seventh grade male students were selected voluntarily from one junior high school in Korea, and a 4 X 6 (Fidelity Levels X Number of Lessons) posttest-only experimental design was employed. Even though the result failed to support main hypotheses due to no distinct difference among fidelity levels of CBIS, the result shows that a cost-effective point on learning time exists in a given level of fidelity of CBIS. Therefore, the hypotheses need to be tested again in further well-designed experiments with a larger range of fidelity.

Theoretical Background

Fidelity means "how closely a simulation imitates reality" (Alessi & Trollip, 1991). The relationship between the levels of fidelity and transfer of learning has been an important issue in the field of training simulators because the levels of fidelity are deeply related with the cost of the simulator (Miller, 1974; Buam *et al.*, 1982; Su, 1984). In addition, controlling the levels of fidelity has been considered to achieve cost effective transfer of learning (Hays & Singer, 1989). Though the flexibility of switching fidelity levels in Computer-Based Instructional Simulation (CBIS) enhances the importance of controlling fidelity levels and its benefits, there are few case studies. Thus, this study focuses on how to determine the optimal shifting points of the fidelity levels on the basis of the relationship between the amount of the learning time and transfer of learning in Computer-Based Instructional Simulation (CBIS).

Case studies on the relationship between fidelity and transfer of learning have yielded different results. One viewpoint is that the higher fidelity of simulation, the better effect of learning (Ornstein, *et al.*, 1954; Dougherty, *et al.*, 1957, Allen, Hays, & Buffardi, 1986). These study results are based on the traditional theory of identical elements (Thorndike, 1913-1914; Yum, 1931; Gibson, 1939; Osgood, 1949). On the other hand, a second point of view maintains that better transfer of learning may be attained through lower levels of a simulation fidelity for students in their early stages (Valverde, 1973; Boreham, 1985), because the higher fidelity of simulation may raise the complexity of instructions, which decreases the effect of learning (Alessi, 1988).

The synthesized assumption was presented by Miller (1974), Alessi (1988), and Hays and Singer (1989). They suggested that the levels of fidelity are decided according to the "stages of learning," that is, "the student's current instructional levels," and the most cost effective simulation learning is that the higher levels of fidelity replace the lower levels as the instructional levels of students improve. In addition, Roscoe (1971) and Povenmire and Roscoe (1973) have shown that the cost effectiveness of learning in the certain level of fidelity is inversely proportional to the amount of learning time.

Research Questions

This study supposes that each level of fidelity would draw a different increasing curve of transfer of learning according to the learning time (Hypothesis I) as presented Figure 1. If the assumption of Figure 1 is true, the optimal shifting time from Fn-1 to Fn, or from Fn to Fn+1, would be determined at the point where the gap of transfer of learning between the consecutive two levels of fidelity (Fn-1 and Fn, or Fn and Fn+1) is maximum (Hypothesis II, Figure 2). Therefore, the suitable shifts of the fidelity levels according to the learning time would have learners reach the goal with less time in CBIS.

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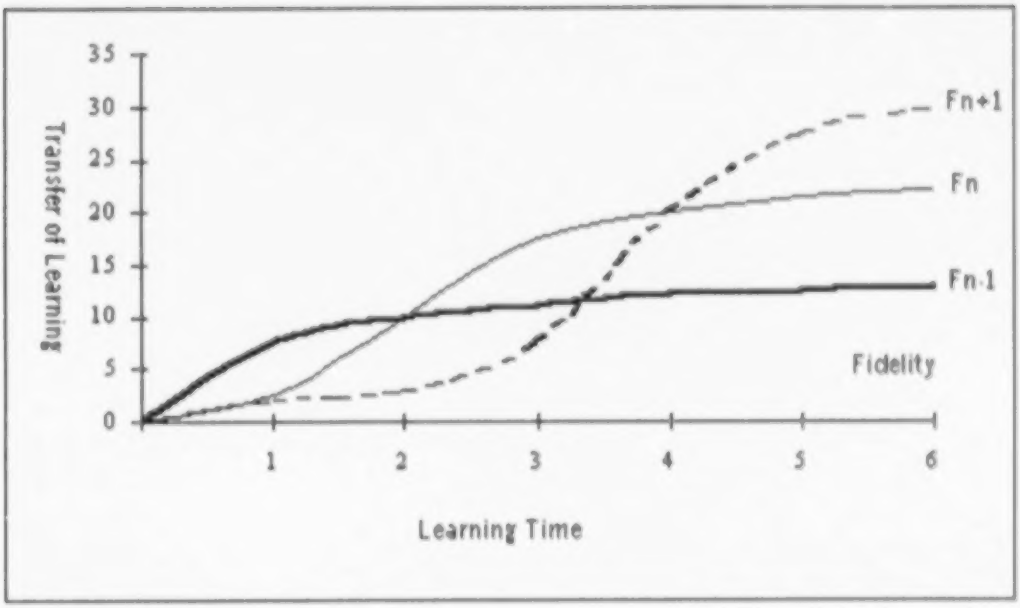

Figure 1. Relationship between transfer of learning and learning time according to fidelity levels (Hypothesis I)
Note: Fn: Given level of fidelity. Fn-1: Lower fidelity than Fn. Fn+1: Higher fidelity than Fn.

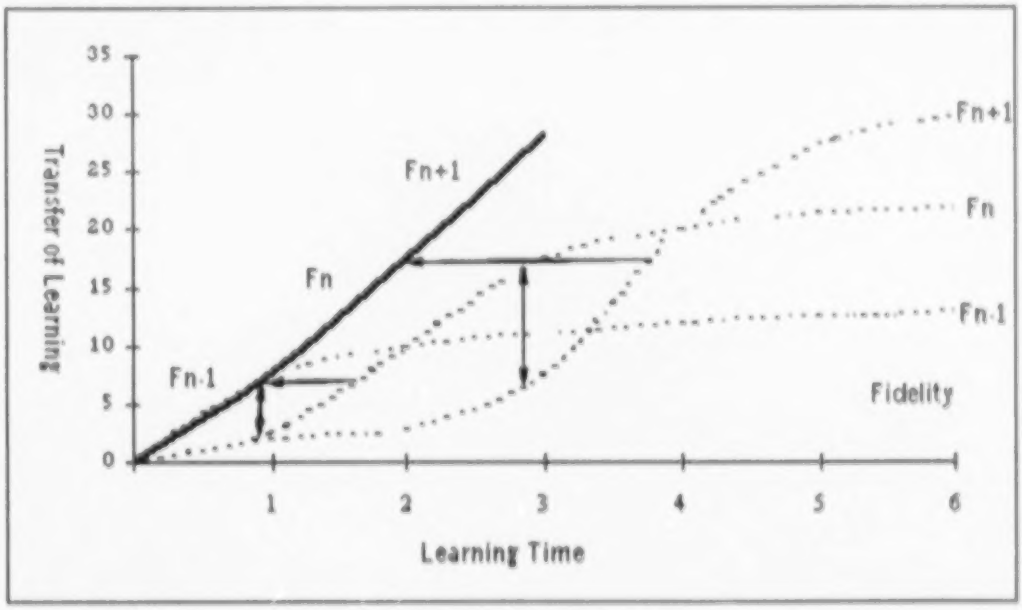

Figure 2. Optimal shifting of fidelity levels and its benefit (Hypothesis II)
Note: Fn: Given level of fidelity. Fn-1: Lower fidelity than Fn. Fn+1: Higher fidelity than Fn.

Research Method

Sampling and Experimental Design

To verify the above hypothesis I presented in Figure 1, 148 seventh grade male students were selected voluntarily from one junior high school in Korea. They had already taken the same classes about the basic use of the Windows 3.1 system in IBM compatible computers. For the experiment, a 4 X 6 (Fidelity Levels X Number of Lessons) posttest-only design was employed.

Operational Definitions

In this experiment, fidelity level means the number and flexibility of actions that the student may take in operating simulation. The learning time is the number of simulation lessons that the student took. Transfer of learning refers to the amount of profit generated by the student through the manipulation and utilization of several variables during the posttest business simulation.

Material

The content of instruction was limited to basic knowledge and common sense in economics, which is treated as a social science subject in the fifth and eighth grades. The students ran the simple fruit store in CBIS. A CBIS program with four different levels of fidelity was developed. Table 1 shows the standards used for classifying the different levels of fidelity in the CBIS development process.

Table 1. The standards for classifying the levels of fidelity

	The factors of classifying	The levels of fidelity				
		1	2	3	4	E*
Number of action	Determination of fruit order quantities	Yes	Yes	Yes	Yes	Yes
	Determination of fruit sale prices	No	Yes	Yes	Yes	Yes
	Selection of fruit types	No	No	Yes	Yes	Yes
Flexibility of action	Number of fruit types to sale/ Total number of fruit types to select	NA	NA	1/2	2/3	2/3

Note: *E means the fidelity level of posttest simulation.

Procedure

The students were randomly assigned to the four groups of differing levels of fidelity, and they practiced the CBIS set at their group's level of fidelity for two minutes. Immediately thereafter, they were evaluated for two minutes by the posttest simulation, which was the highest level of fidelity. In this manner, two minutes practice and two minutes test were repeated six times to estimate the curve of transfer of learning. The responses of the students, the net profits during the test simulation, were recorded in the computer.

Results

[1] As presented Figure 3, there were no differences among the four increasing curves of transfer of learning which each level of fidelity drew through the learning time. [2] Meanwhile, the transfer of learning for the CBIS varied with the six gradual stages of learning time, $F(5, 739)=36.3$, $p<.001$. The post-hoc analyses indicated that the transfer of learning curve marked a sharp rise at the first and second simulation lessons (learning time) with statistical significance, and then it flattened out after the second lesson (Figure 3).

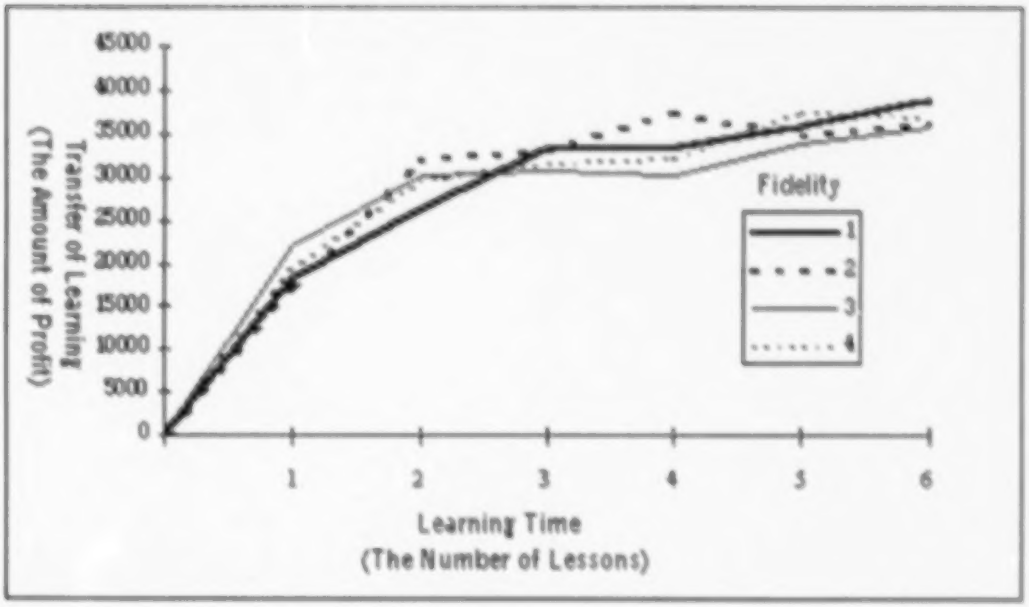

Figure 3. Relationship between transfer of learning and learning time according to fidelity levels (Result)

Discussion & Implication

The result [2] supported by Roscoe(1971) and Povenmire and Roscoe(1973) implies that CBIS has the cost-effective point on the amount of learning time. In this case, it is most cost-effective to stop instruction after the second simulation lesson.

The result [1] has two possible interpretations. First, the lack of an effect by the levels of fidelity on the transfer of learning in this experiment may be attributable to the lack of any real differences in the levels of fidelity of the CBIS developed. Actually, this assumption (Figure 1) is based on Alessi's comprehensive model (1988); the fidelity levels should be determined by a variety of aspects-underlying models, presentations, user actions, and system feedback- and a wide range of situations-form the low level fidelity to the actual experience. In this experiment, however, the four different levels of fidelity considered only the user action aspect, and the close intervals of fidelity levels were all admittedly in a low range due to limited financial resources. Therefore, the assumptions (Figure 1 and 2) will be tested again in further well-designed researches with a larger range of fidelity.

The second interpretation is that the levels of fidelity may be not important variables on transfer effects in CBIS. The researches and claims of Cox, *et al.* (1965), Grimsley (1969), Hopkins (1975), and Johnson (1981) in the field of simulators may be regarded as being consistent with the results of this study. In addition, psychological aspects of fidelity may be more important than the physical aspects of it (Prather, 1973; Dittrich, 1977). Finally, psychological aspects of fidelity in CBIS will have to be considered in further researches.

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